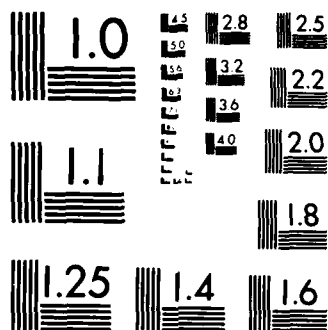END

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ABSTRACT

We examined hardware requirements for development of a Deployable Core Automated Maintenance System (DCAMS). Our six alternatives covered the spectrum from a mainframe computer, the Tactical Shelter System, to the Air Force standard microcomputer, Zenith Z-100. Criteria used for the evaluation looked at ease of maintenance, survivability, physical characteristics, transportability, and compatibility with CAMS. We recommend using a microcomputer network to best satisfy the hardware requirement for DCAMS. Since DCAMS is not funded, we also recommend an interim system be developed by the AFLMC to provide limited support until DCAMS is ready. The system would be developed on the AF standard microcomputer and provide engine tracking, scheduled maintenance requirements, and aircraft status information.

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EXECUTIVE SUMMARY

Development of a Deployable Core Automated Maintenance System (DCAMS) will enhance the combat capability of aircraft maintenance units. Therefore, it is vital to select the best possible hardware/software combination to ensure rapid and cost efficient fielding of this critically needed capability. After reviewing expected future maintenance requirements and evolving computer technology we developed six alternatives. Based on our analysis of these alternatives, we recommend a microcomputer network to meet DCAMS needs.

We reviewed the current methods used to support deployed aircraft maintenance units. Aircraft are now selected by a deploying unit according to available flying time remaining before a scheduled major maintenance action (engine change, major inspection, etc.). While deployed, if a phone line is available, daily calls are made to relay flying time, maintenance problems, and engine data for tracked engines to the home base's data collection system. Other maintenance data is generally collected for input upon return from the deployment; unfortunately, large amounts of data are frequently lost. For small deployments, 12-14 aircraft for 15-30 days, the aircraft AFTO Forms 781 series are the only historical records generally taken along, necessitating almost total reliance on the home station for any other maintenance data not contained in the 781. Modular engines, such as the F-100 engine used in the F-16 and F-15, require individual components be tracked to ensure none are overflown. We have determined the amount of time required to make all the necessary engine component calculations and are confident the deployed units do not do them.

The alternatives we examined were: Null, do not develop DCAMS; a downsized Sperry Emulator; the Tactical Shelter System; a minicomputer (Combat Supply System); a microcomputer network; and a single microcomputer (Zenith Z-100). We analyzed each alternative using size, transportability, cost (initial and life cycle), software risk, hardware risk, similarity to CAMS, maintenance concept, electrical power requirements, survivability, number of terminals, and number of communications ports. A detailed summary of the analysis is attached (Atch 1).

A microcomputer network provides the best survivability, is easily transported, and is flexible enough to adapt to various MAJCOM management structures. We recommend DCAMS be developed as a stand-alone network for use by an aircraft maintenance unit (AMU) or organizational maintenance squadron (OMS) flightline section. The network would perform the necessary processing for the unit to manage assigned aircraft. It would be connected to the Phase IV system and interact with CAMS while at home station, and operate as a stand-alone system when deployed.

This concept will require purchasing of specialized microcomputers capable of operating efficiently in a network. It will also require Air Force programmers to become proficient in distributed processing and shared processing to develop application software. As no money has been approved for DCAMS development, we do not expect to see an operational system in the field for at least three years. Field units that can be deployed cannot wait that long. Therefore, we recommend an interim system be developed to provide the

minimum capabilities of DCAMS. This system would only be capable of limited support for field units. As a minimum, it would perform aircraft scheduling, engine tracking, and status monitoring. The first two programs have already been developed, leaving the status module. All three programs can be available to run on the Z-100 computer in one year.

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CHAPTER 1 - THE PROBLEM

1. Background.

a. Maintenance management will be significantly changed when the Core Automated Maintenance System (CAMS) is implemented. Most maintenance management processes are paper intensive and manually accomplished with batch processed computer support. Since we now have a manual input system, the loss of computer support either at home station or during deployments has minimal effect on management processes. The manual input forms are collected during a power outage for computer entry when the computer is back up or during deployment for entry when the unit returns to home station. This environment will change when CAMS becomes operational.

b. CAMS will fully automate maintenance management by providing an on-line computer system with terminals in or near each workcenter. The majority of maintenance data will be entered directly by the originator and retrieved directly by the user. Supervisors will become increasingly dependent on the automated management processes, and our young airmen will be unfamiliar with how to follow manual procedures. This dependence and lack of familiarity will make returning to non-automated data systems extremely difficult and runs the risk of losing valuable maintenance data.

c. During deployments, manual data systems must be used since an automated system has yet to be developed. CAMS is to be a mainframe-based program capable of use only on the Phase IV Sperry 1100/60 base computer. Without a deployable automated system, maintenance personnel will be forced to revert to resource consuming procedures, like handwritten logs, when resources are limited and time is precious. Therefore, a Deployable Core Automated Maintenance System (DCAMS) must be developed. The Director, Maintenance and Supply, HQ USAF/LEY tasked the AFLMC to compile a list of hardware/software options for DCAMS.

2. Problem Statement.

DCAMS is to be developed by the Data Systems Design Office on new computer hardware that is compatible with Phase IV equipment. Many types of hardware and software configurations are available to meet the DCAMS requirement. However, an obvious choice is not apparent when transportability, ease of operation, cost effectiveness, and compatibility with Phase IV CAMS software are considered.

3. Factors Bearing on the Problem.

a. Issues. If identical systems were used for both CAMS and DCAMS, development and system maintenance costs could be minimized. DCAMS and CAMS will use some of the same processes. However, the computer program being developed by the DSDO for CAMS will run only on the Sperry Phase IV computer. To run on any other computer, the source code would have to be translated. That would require a considerable amount of time and resources.

b. Constraints.

(1) Selected equipment must be easily transportable and immune to most environmental conditions.

(a) Equipment must operate on available electrical power, i.e., local country, generator, etc, 110-220 VAC, 50-60 HZ. Power conditioning can be accomplished internally or externally to system, but requirements must be considered.

(b) Individual components must be sized to be easily carried by one individual.

(c) Tempest requirements must be considered.

(2) The system must interface with existing and planned communications systems, including DDN and satellite terminals. An electronic interface is preferred.

(3) The system must operate in a stand-alone mode at the deployed location. If other systems, i.e., Combat Supply System, Combat Logistics System, etc., are available, electronic data exchange capability should be considered.

(4) As a minimum, DCAMS will be sized to support one squadron (up to 24 aircraft) per system. Expansion to wing level support will be considered.

(5) The equipment must be compatible with CAMS hardware and software.

Current Method. We reviewed the current methods used to support deployed aircraft maintenance units. Aircraft are now selected by a deploying unit based on available flying time remaining before a scheduled major maintenance action (engine change, major inspection, etc.). While deployed, if a phone line is available, a daily call is made back home to relay time sensitive data such as flying time, maintenance problems, and engine data for tracked engines. Other routine maintenance data is generally collected for input upon return from the deployment; unfortunately, large amounts of data are frequently lost. For small deployments, 12-14 aircraft for 15-30 days, the aircraft AFTO Forms 781 series are the only historical records generally taken along, necessitating almost total reliance on the home station for any other maintenance data not contained in the 781. Modular engines, such as the F-100 engine used in the F-16 and F-15, require individual components be tracked to ensure none are overflown. We have determined the amount of time required to make all the necessary engine component calculations and are confident the deployed units do not do them.

Current procedures are inefficient and need to be replaced with an automated system. Understanding the present system for deployments allowed us to develop criteria and various alternatives for examination.

Methodology.

a. First, evaluation criteria were developed using the technical expertise of our analysts, the CAMS Functional Description, DCAMS Requirements Meeting minutes, and other data sources as needed. The criteria provided a uniform rating system for evaluating various hardware options.

b. Next, data on hardware capabilities was collected. The Combat Supply System request for proposal was reviewed. The AF standard microcomputer, Zenith Z-100 capabilities were reviewed at the AFLMC. AFASPO and Sperry marketing representatives provided information on Sperry equipment. Data was gathered on other hardware to determine what could meet the DCAMS requirement. A trip to Cherry Point Marine Corps Air Station, NC, was made to look at a new deployable system being developed by the Navy.

Finally, the various hardware options were evaluated using the established criteria. This evaluation determined the hardware that best meets requirements.

This report shows the selection procedure and results.

3. Evaluation Criteria. Each alternative was analyzed to determine how well it met a set of criteria. The criteria we used are shown below along with a brief description.

a. Size. DCAMS is a deployable system mandating an easily transportable unit. Airlift is already critical, and the selected hardware should not increase airlift requirements.

b. Transportability. Selected hardware must be easily moved, set up, and taken apart. No special handling equipment should be required. Individual pieces should weigh less than 120 pounds each. Equipment must not be susceptible to damage in transit. Set up time from arrival to full operation should be less than one hour.

c. Cost. Both acquisition cost for hardware and development cost for software was considered. Software maintenance for the life of the system was also considered for those alternatives requiring separate software from CAMS.

d. Maintenance Concept. DCAMS hardware should be maintainable by the user with self-diagnostic software to the circuit card level. Less than eight hours of training should be required for technicians to be able to perform maintenance on the hardware. Systems that require specialized personnel for maintenance and operation were considered less desirable.

e. Electrical Power Requirements. Hardware should be switchable to operate on 110-220 VAC 50-60 HZ. Power conditioning for spikes, etc., could be performed externally. Battery power to prevent loss of data in case of external power failure should be provided.

f. Survivability. The equipment should not be an obvious target. It must withstand limited shock/vibration while operating. Some redundancy should be included to ensure continued usability.

g. Number of Terminals. Sufficient terminals should be available for easy access. For a deployed squadron accustom to the CAMS environment, seven to ten data entry devices are needed.

h. Number of Communications Ports. The deployed unit will be required to furnish status and mission data to home base and higher headquarters. Electronic transfer of data appears to be the most efficient method. DCAMS should electronically interface with any communication system (i.e., SATCOM, AUTODIN, or AUTOVON) available at the deployed location. Also, other deployed systems will have important data needed by maintenance or vice versa. Additional ports and protocols will be needed to communicate electronically with the Combat Supply System, Combat Logistics Systems or other deployed computer systems.

4. Evaluation Factor. We also used the following factors in the evaluation of alternatives.

a. Software Risk. This was an assessment of risk to develop new software which is dependent upon the type of programs being developed. Programs using newly developed techniques such as networking, etc., have higher risk than a "straight forward" program.

b. Hardware Risk. This included an assessment of the risk of the hardware in each alternative. New development, i.e., an emulator, will have a greater risk than commercially available hardware. Also, systems emerging from technology have greater risk than established, proven systems.

c. Similarity to CAMS Software. The direct use of the CAMS software for DCAMS will reduce the amount of software the Data Systems Design Office has to

maintain. However, ability to directly use the CAMS code requires specific computer hardware and operating systems, thus limiting hardware choices.

5. Alternatives. The following six possible alternatives were analyzed. Each alternative is presented with a brief description and discussed as to capability to meet DCAMS hardware needs.

a. NULL, Do not Develop DCAMS. Maintenance managers need access to the data presently stored in the base mainframe computer system on a daily basis. During deployments, home base computer access is not available, and managers must perform inefficient manual work-arounds. Therefore, this option does not satisfy management needs nor satisfy known requirements being developed in CAMS. Deployed units with new aircraft must have engine tracking, and all units need scheduled maintenance data. Under CAMS, maintenance personnel will rely on on-line computer systems for daily support at home base. Additionally, they will have to be familiar with manual procedures when they revert back to hand-scribed records when deployed. This necessitates additional training and results in decreased effectiveness when maximum combat capability is critical.

b. An Emulator Capable of Processing CAMS Software. Computer equipment to satisfy this option presently does not exist. This system would run the CAMS software since it would electronically emulate an 1100/60. Development of this capability would require rights to the Sperry 1100/60 computer operating system and specific hardware design data. Without access to that data, it would be impossible for any company except Sperry to develop an emulator. This could force us into a sole source contract effort.

If the US Government has rights to the necessary data, a competitive contract could be let for system development. Litton Data Systems developed an emulator of the Burroughs B3500 computer while under contract with the AFLMC. Using government-owned data, they developed the emulator in about 18 months. This was for a 1960s technology computer system. The Sperry 1100/60 is a more capable computer system and more technologically current which increases the difficulty of developing an emulator that is small enough to be easily deployable. We estimate the cost at between two and five million dollars for prototype development. A production system would probably cost from $300,000 to $750,000 per system. These estimates are based on the cost to develop the B3500 emulator and the projected cost per unit.

This alternative has several advantages. One set of software for CAMS and DCAMS ensures a unit operates the same at home station and when deployed. The system is identical; no additional training would be required on system operation.

A major disadvantage is the risk associated with a development effort and the time necessary to develop, test, and procure the hardware. Even though CAMS software is used the risks may outweigh the benefits.

An alternative to emulation but similar approach would be to develop the CAMS software on a separate system. To the user it would appear to be the same system but written to be run on separate hardware. The disadvantage to this approach is the introduction of additonal software for the data systems

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design office to maintain. These costs could be reduced through modular software design by having some joint CAMS and DCAMS processes on only the DCAMS system that, while used at home station, is connected to Phase IV.

The economic analysis for CAMS listed life cycle costs to maintain two sets of software, CAMS and DCAMS, at $10,000,000. Modularizing the CAMS software should reduce these costs as some options in CAMS and DCAMS would be in only one place, eliminating the need for duplicative sets of software.

c. Tactical Shelter System (TSS). The TSS is a Sperry 1100/60 computer built into four air transportable shelters. Each shelter provides its own environmental control and power source. This system would add one C-141 load to each deploying squadron's equipment. With each unit usually constrained on the amount of airlift programmed and with documented shortfalls in total airlift during actual contingencies, extra airlift is not guaranteed to add this required capability.

The TSS is also very costly. Each system is projected to cost $2,800,000. This is a total of $590,000,000 for 211 systems, the required number of DCAMS systems from the DCAMS delivery schedule, dated 24 May 83.

Common software is a distinct advantage and does offset procurement cost with reduced lifecycle costs for maintenance of a separate DCAMS software package. As previously stated that cost is $10,000,000 for 20 years.

This alternative was rejected due to airlift requirements, which would increase the projected airlift shortfall, and system cost. Even with the offsetting cost of having only one set of software to maintain, this option is extremely expensive.

d. Minicomputer. The original requirements for the Deployable Combat Support Systems (Combat Supply System) were used as the baseline for this option. The Combat Supply System (CSS) procurement is in final contract negotiations. The hardware is expected to be a minicomputer with at least seven terminals. Projected costs are less than $100,000 per system for about 70 systems.

The CSS will be used as a front-end processor with a Phase IV computer at base level. Those units that are authorized a War Readiness Spares Kit (WRSK) will have a CSS assigned. All WRSK management on a day-to-day basis will be performed in the CSS. The CSS will exchange data automatically with the Standard Base Supply System on the Phase IV Sperry 1100/60 computer. When the WRSK is deployed with the assigned unit, the CSS will be disconnected from the Sperry 1100/60 and deployed. It will provide a WRSK management system for the deployed unit independently for up to 60 days along with other capabilities.

The system has been specified in the request for proposal to be easy to maintain and very reliable. The user will have diagnostic software to troubleshoot the system and isolate malfunctions to the replaceable unit.

This option does meet most of the criteria necessary for a DCAMS system. It is easily deployable and the cost is not prohibitive. The CSS, or a similar minicomputer, would require a new set of software. By using the

technique being planned for the CSS, some portions of the CAMS software could be resident only on a minicomputer system in the local unit and never be included in CAMS on the Phase IV computer. This reduces the amount of duplicative software for CAMS and DCAMS. DCAMS programs would run on the DCAMS hardware at home station interfacing directly with CAMS and independently when disconnected from CAMS and deployed.

The major disadvantage of this system is the characteristics of a minicomputer. Having a single minicomputer with a single central processing unit (CPU) increases the probability of system outage due to malfunctions or damage. The high reliability and planned user maintenance concept can not completely eliminate system downtime. Maintenance managers will become increasingly dependent on the system once it becomes available. Loss of the system will greatly compound management problems after several years of a fully automated management environment, both at home station and when deployed. Reverting to manual procedures will be extremely cumbersome and ineffective.

This alternative for a minicomputer is rejected for the lack of survivability and redundancy inherent to the system. This alternative does meet the needs for a DCAMS system but compared against all alternatives, the single minicomputer does not provide the redundancy of a microcomputer network. Here, if a CPU becomes inoperable for any reason, all processing stops; the system is down until the CPU is repaired.

c. Microcomputer Network. Any microcomputer system that can efficiently operate in a local area network was included in this option. A microcomputer is a stand-alone, table top-size computer, usually with one keyboard and visual display terminal. Memory size, disk devices and other peripherals will vary by manufacturer and system configuration. Local area networks (LAN) allow several microcomputers to be connected in a circuit to share programs and data while retaining the capability to operate independently. If one computer malfunctions, the remaining computers on the LAN will be able to continue to operate. The LAN uses one of the microcomputers as a network controller to insure communications on the LAN are possible; however, the controller function can be shifted to another microcomputer.

This option also requires an additional set of DCAMS software. Using the concept at optimum efficiency, the DCAMS LAN should be used daily in the unit as a part of CAMS. Some functions now planned for inclusion in CAMS programs could be developed for use only on the DCAMS hardware. Those units without a deployment mission could use the same system as a front-end processing system using similar hardware that was not built for deployment (commercial version).

Deployability and survivability are enhanced with a LAN and a microcomputer. Systems currently available have the demonstrated capability to meet DCAMS requirements for a multitask computer system that will operate efficiently in a LAN. With the known delay in DCAMS funding, the variety and capability of commercially available systems will dramatically increase. These systems will reduce the risk and cost for this option. Very capable microcomputers are commercially available and easily transportable. They are generally small, self-contained units with large memory and data storage capacity. Repackaging to enhance ruggedness and transportability is feasible through contract specifications, but not without adding cost.

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Government and commercial installations of LAN's are increasing rapidily. A LAN is presently being brought into the Air Force through a project at Gunter AFS. The Data System Design Office is managing the installation of a LAN that will interconnect many users at widely seperated locations on the base using off the shelf equipment. Commercial installations interconnecting large office buildings or complexes are becomming common place. IBM has announced an IBM PC network that will be available in early 1985. In an article from the 20 Aug 1984 issue of Computerworld, Joseph Hughes marketing vice-president of Corvus systems, Inc stated "I predict a fivefold increase in personnel computer network installations in the next year." Proven systems will be available to meet all DCAMS needs.

Multiple microcomputers for a DCAMS system allows several fallback positions in the event of equipment malfunction or damage. A full configuration would entail 5-10 microcomputers on a LAN. Several computers could be lost without total disruption of the LAN, and each microcomputer would still have the capability to operate independently. Disruption of the LAN would allow individual computers to process and collect data in the stand-alone mode, but distributed processing and data transfer may be lost to some stations while the LAN is being repaired. As all the microcomputers would be identical, all independent programs could run on any computer, giving great flexibility in maintaining residual processing of essential functions until the LAN and individual computers could be repaired.

Microcomputers and LAN technology are advancing rapidly with an associated decrease in prices. A LAN with up to seven microcomputers could be purchased in an off-the-shelf, commercial configuration for about $32,000 per system.

f. Microcomputer. A single microcomputer, specifically the Air Force standard microcomputer, the Zenith Z-100, was evaluated in this option. The single microcomputer is fully capable of performing many necessary functions in a deployed environment. It is easily deployed and maintained by users. It is planned that the Z-100 will be able to interface directly with the Sperry 1100/60 in the CAMS environment and function as a smart terminal, being able to independently process data from the mainframe.

The greatest deficiency with the use of a single microcomputer for DCAMS is the inability to pass data electronically, automatically, and efficiently. Distributed processing using a LAN entails shared data that is accessed automatically as specific application programs require it. A single microcomputer can pass data files electronically, and the individual computer can then run its own programs using that data. The data transfer is usually not fully automated and some operator input is required. This deficiency could necessitate numerous transfers, or the manual input of data to ensure the most current data is used. This makes a system of independent microcomputers too cumbersome for this operation.

Access to terminals to input or retrieve data is more difficult when using single microcomputers. Different managers and technicians may use the same data in various ways. Each must have access to some common data and yet have exclusive data. The common data would have to be entered into each machine independently. This approach may create backlogs and inaccurate data files.

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These limitations cause rejection of the single microcomputer option.

5. The project team also created the following matrix, Fig 2-1, to permit easier comparison of alternatives. The chart shows physical characteristics of the evaluated systems.

PHYSICAL CHARACTERISTICS OF OPTIONS

		PER SYSTEM			COMPATIBLE WITH	
OPTION	PRICE	APPROXIMATE SIZE	ELECTRICAL POWER	NUMBER OF TERMINALS	CAMS SOFTWARE	CAMS DATA
EMULATOR	$300-750 K	Table Top CPU (1)	110/220	10-50 as needed	Yes	Yes
TSS	$2,800 K	4 Large Vans	110/220 Generator	50+ as needed	Yes	Yes
MINI- COMPUTER (CSS)	$60-80 K	Table Top (1) CPU (2)	110/220	7	No	Yes(4)
MICRO- COMPUTER NETWORK	$32 K	Size Of 8 Micro's(3)	110/220	7	No	Yes(4)
MICRO- COMPUTER	$5 K	Size of Micro	110/220	1	No	Yes(4)

NOTE: 1. CPU would fit on desk. Peripherals (hard disk drive, line printer, system controller, etc) would add to space needed, terminals extra.

2. CPU would fit on desk, terminals extra.

3. Based on existing hardware.

4. Can be programmed.

Figure 2-1

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CHAPTER 3

CONCLUSIONS

The null alternative of not developing DCAMS is infeasible because of the changes coming in CAMS over the next four to five years. If we do nothing to cover when the full system is down or unavailable (like when a unit is deployed), we may (or will) not be able to cope with manually processing maintenance information needed to perform the mission (like tracking the modules on the F-100 engine to keep the aircraft flying). Therefore, the question is not whether a deployable system should be developed, but what hardware should be used for a DCAMS.

Our analysis of the various types of hardware systems easily ruled out several. The Tactical Shelter System is too large because it would add a C-141 load to each deploying squadron. The single microcomputer is too limited to support all of its requirements, and has only one keyboard and CRT. The emulator of a Sperry 1100/60 mainframe computer has major advantages over other options. Although it would run CAMS software and could be designed for easy deployment, it could not be available until 1990. We need DCAMS before then; therefore the emulator option is unacceptable. Of the remaining options, even though the hardware for the Combat Supply System meets most needs, it appears the hardware will be a minicomputer and is eliminated for survivability. Loss of the central processing unit would leave the deploying unit with no support. The remaining option, microcomputer network is selected as best satisfying our criteria.

CHAPTER 4

RECOMMENDATION

A microcomputer network provides the best survivability, is easily transported, and is flexible enough to adapt to various MAJCOM management structures. The network would perform the necessary processing for the unit to manage assigned aircraft. It would be attached to the Phase IV system and interact with CAMS while at home station, and operate as a stand-alone system when deployed. Recommend DCAMS be developed as a stand-alone network to be used by an aircraft maintenance unit (AMU) or organizational maintenance squadron (OMS) flightline section. (OPR: HQ USAF/LEY)

This concept will require the purchasing of specialized microcomputers with the capability to operate efficiently in a network. It will also require Air Force programmers to become proficient in distributed processing and shared processing to develop application software. As no money has been approved for DCAMS development, we do not expect to see an operational system in the field for at least three years. Field units with a deployment mission will not be able to wait that long. An interim system could be available to run on a Z-100 computer in one year. This system would only be capable of limited support for field units. As a minimum, it would perform aircraft scheduling, engine tracking, and status monitoring. The first two programs have already been done, leaving the status module to develop.

The AFLMC would provide the computer programs and user's manuals to MAJCOMs needing the interim system. We would provide maintenance of the computer program to ensure it will continue to function until the Air Force DCAMS system is ready. Software maintenance would include both support to keep the system operating and essential enhancements.

The interim system would consist of three parts. We would integrate the Automated Flying and Maintenance Scheduling System, (AFAMS), Minimum Essential Engine Tracking System (MEETS) and a third module to perform status and history tracking. We envision the system would carry sufficient aircraft history from home station to satisfy maintenance managers. All work orders would be entered and stored in the system providing a completed history while deployed.

This would only provide a limited, interim capability. It is not designed to replace DCAMS but to provide some computer support until DCAMS can be funded and developed. The Air Force has passed the point where a unit can deploy and operate efficiently without some computer support. Implementation of CAMS will make a deployment harder if maintenance personnel have to revert from an on-line computer system to manual procedures.

We recommend development of an interim system to provide minimum capabilities. (OPR: AFLMC)

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